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PLANT DISEASES

OF 1901.

—BY—

WENDELL PADDOCK.

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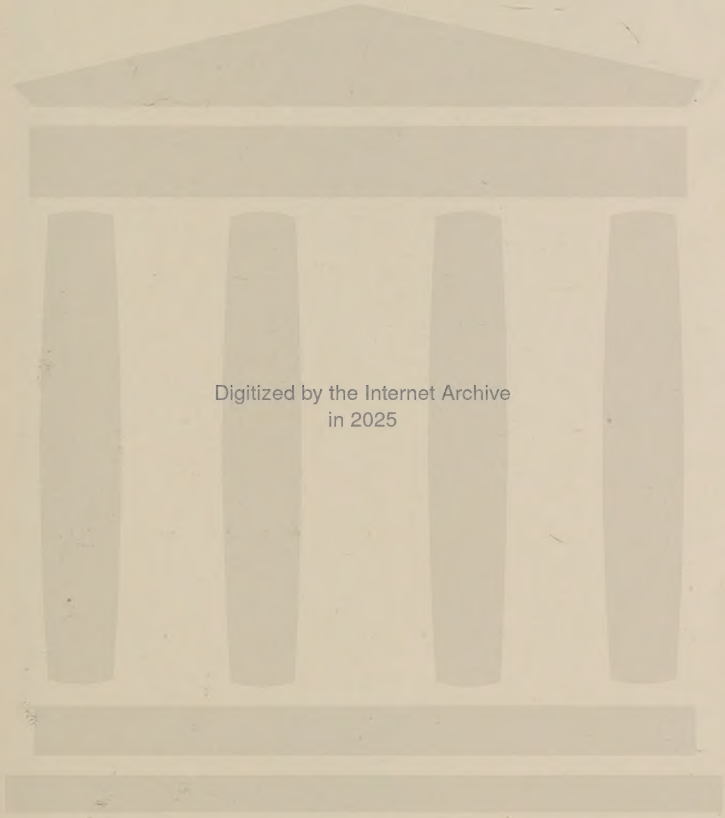

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PLATE I.

Apple trees killed by too much water and root rot.

PLANT DISEASES

OF 1901.

By WENDELL PADDOCK.

INTRODUCTION.

A brief account is given in the following pages of some of the plant diseases which have come to our attention during the past season. Only a few of these were brought to our notice by correspondents, and it is the purpose of this bulletin to stimulate a greater interest in the subject, for it is reasonable to suppose that these pests of our crops will increase in Colorado as they have done in older States. By prompt attention many of them may be overcome or controlled. In a State so large as ours it is impossible for one or two men, with the time at our disposal, to visit very many different localities. It is, therefore, desirable in the interest of all that any untoward condition of crops, be it due either to insects or fungi, should be reported to the Experiment Station. Specimens of the affected plants should in all cases accompany the report.

Now a word as to the nature of plant diseases. This term is commonly applied to a class of plants known as fungi, and sometimes to the result of unfavorable soil or atmospheric conditions, but rarely to insect attacks. The following pages have to do mostly with fungi. These plants are low in the scale of development and are mostly of microscopic size, though some of them, as toad stools and puff balls, are familiar objects. Plants of this class are unable to take nourishment from the soil, consequently they must live on food that has been prepared by other plants. Many of them live on decaying vegetable matter, but others are true parasites, attacking live plants and thus becoming of economic importance. These tiny plants have organs that correspond to the roots, branches and seeds of higher plants.

The seed-like organs or spores, go through a process of germination much the same as a grain of corn. Being so small they are readily borne about by the wind and when they chance to fall on the kind of plant to which the fungus is adapted—its host plant—and the conditions are favorable for germination, the fungus readily gains a foothold.

It has been found that spores are unable to germinate in the presence of small amounts of copper, and advantage is taken of this fact when plants are sprayed with Bordeaux mixture. The copper in the mixture protects plants, hence the better the spraying is done the more complete is the protection. The fact that Bordeaux is not a cure should be borne in mind, and to be a successful preventive it must be applied before the spores are disseminated.

Fungi that live in the soil and attack the roots of plants are not dependent on spores as a means of dissemination. The root-like organs, or hyphæ, spread through the soil from plant to plant, or they may be distributed by the cultivator or other means. With root diseases the treatment is more complicated, since there is usually no way of telling that a plant is affected until it is past recovery. A systematic rotation of crops is often of help in keeping annual and biennial plants healthy, but with orchards little can be done after the trees are attacked. Good care in every respect will be a great aid in keeping the trees free from disease.

Many of the fungi which produce disease in plants are invisible to the unaided eye, hence they are apt to be regarded as something mysterious and the effects are often ascribed to other causes. The action of climate, altitude, winter injury, alkali and water are often mistaken for the effects of attacks of fungi. For example, the potato failures in the vicinity of Fort Collins have long been thought to be due entirely to peculiar conditions of soil and climate, notwithstanding the fact that the famous Greeley potato district lies only twenty miles east and in the same altitude. Experiments conducted at this station during the past year prove that the lack of success is due primarily to root diseases which thrive much better in our heavy soil than in the lighter and better drained soils in the potato district. The fact that we have occasional successes here is no doubt largely due to planting clean seed in soil that is free from disease, or the conditions are not suitable for the best development of the fungi during certain seasons.

APPLE TREE ROOT ROT.

The presence of an unusual amount of yellow foliage on fruit trees last spring attracted attention in various localities in Northern Colorado. It is a well known fact that too much water will produce yellow foliage, and this is the cause that is commonly thought to be accountable for this condition. As the leaves usually regain their normal color before the close of the season but little attention is given to the subject. An unusual amount of rain in the early summer was probably the cause of this general appearance of yellow foliage, but many fruit growers have noticed that occasional trees are affected in this manner year after year and finally die without any apparent cause, while adjacent trees remain healthy. It is not

PLATE II.

Winter injury of apple trees induced by peculiar soil conditions.

PLATE III.

Blackberry roots injured by Rhizoctonia. Natural size.

uncommon for such trees to die in the latter part of summer, when the fruit and foliage wither and cling to the dead branches. Such trees are usually comparatively loose in the soil, in fact, some of them may be tipped over while they are yet alive. Upon examination the larger roots will be found to be in an advanced stage of decay, and the feeding roots finally become so reduced that there are not enough left to support the tree.

Certain fungi are constantly associated with the diseased roots, and it is probable that they are ultimately responsible for the death of the tree. As a result of numerous examinations, it was found that these same fungi also attack the roots of trees that are apparently healthy. Now it is easy to conceive that these diseases may live on the roots of a tree for a number of years without doing much harm, but as soon as the tree is weakened from any cause the fungus makes rapid advance.

Trees that take on yellow foliage from overirrigation suffer a temporary check in growth, from which they apparently recover in a short time. But if this is repeated year after year the ultimate effect must be very injurious. A wet, heavy soil, however, produces ideal conditions for the growth of root destroying fungi which appear to be abundant in our State, and when a favorable opportunity occurs they become destructive.

Winter injuries, which result in sun scald, black heart, freezing of the roots and dry freezing of both roots and branches, are potent causes of the weakening of the vitality of trees in some sections of the State. Trees may be injured in some one of the above ways and yet not show any marked indication that anything is wrong.

A good deal of damage is also done to fruit trees by the attacks of wooly aphis, which are abundant in many localities. They increase rapidly if left undisturbed, and the greater portion of the root system may soon be infested. These conditions result in serious injury and trees may even be ruined by such attacks. Root fungi are not slow to take advantage of the enfeebled roots, and it is likely that in many instances they rapidly extend these injuries.

In some localities the natural drainage of the soil is poor, and it is evident that too much water is being used in irrigating. In a number of orchards visited the level of the water in the soil had been raised till the lower roots of the trees were apparently surrounded by a saturated soil most of the time. This is particularly true of small orchards, where the owners grow small fruits or truck crops between the rows to supplement the income from the orchard. Root fungi thrive remarkably well under these conditions, and the combination of causes is doing no small amount of damage. One orchard came under my observation where all of the trees on an area of about two acres had been ruined. (See Plate I.). Another orchardist reports a yearly loss of about 25 out of an orchard of 1,000 trees. Instances of this kind might easily be multiplied.

That the trees are injured by water under these circumstances cannot be doubted, since no agricultural plant can thrive in a saturated soil. We have not yet demonstrated the exact relation which fungi bear to this condition, but it is evident that they play an important part in the destruction of the trees. Certain species are usually found on the roots of diseased trees and attacking healthy tissue. Moreover, young trees have been known to be killed in one season, apparently by root rot, when planted in the places from which dead trees had been removed.

This subject is a most perplexing and important one, and one that is as yet but little understood. We expect, however, to make it one of the principal lines of investigation of this Section for the coming season. In the meantime certain sanitary measures may be mentioned that might well be observed by many orchardists.

When it becomes evident that too much water is being used in irrigating, as is indicated by yellow foliage, or by the raising of the level of the water in the soil, more use might well be made of the cultivator. By keeping the surface of the soil loose much of the water is prevented from evaporating, thus lessening the necessity of frequent irrigation. The trees should be kept in a thrifty condition, and yet not allowed to make a rapid growth, which produces soft tissues that easily succumb to attacks of blight. On some soils it may be best to keep the orchard seeded to alfalfa, but usually better results will follow a systematic use of cover crops. The many advantages to be derived from the use of cover crops cannot be discussed here, but with this system of cultivation some crop is sown in the orchard in late summer or early fall which is plowed under the next spring. Mr. Griffin has found that the best leguminous plant for this purpose at Rockyford is hairy vetch. (See Bulletin No. 68 of this Station). Since this plant is one of the nitrogen gatherers it may not be advisable to use it on all soils; in such cases winter rye may be used instead. In localities where the attacks of blight are severe, it may be advisable not to plow the crop under till late in the spring and thus avoid a rapid early growth of new wood.

APPLE TREE ROSETTE.

A peculiar condition of apple trees was brought to our attention on Rogers Mesa in Delta county by the Horticultural Inspector. More or less of the trouble occurs in a number of orchards in this locality, consequently it is a matter of considerable interest in the county. Some of the trees are dying, while there are a number of dead limbs on others, but the characteristic feature of the disease is a tuft or rosette of small leaves at the end of branches that are otherwise nearly bare of foliage. (See Plate II.). The similarity of this condition to the peach tree rosette, a common disease in portions of

the Southeast, was so great that the presence of a new apple tree disease was suspected.

I visited this section in July and collected numerous specimens, but no parasitic organism could be detected by laboratory investigation. Later on Mr. C. H. Potter visited some of these orchards and made valuable observations on the soil formation. I visited the locality again in September in company with Dr. Headden, and as a result of our observations and study, together with the experience of the fruit growers, we arrived at the following conclusions:

Much of the soil on the Mesa contains an excess of marl and in many places this substance forms a solid substratum. At the edge of one orchard visited the owner was digging and burning it to make a cement to be used in mason work. The marl in itself is, perhaps, not harmful to plants; in fact, when judiciously applied to land it acts as a liberator of plant food, but when present in excess the soil is infertile. This is shown by the fact that when roots penetrate the marl substratum they send out few or no fibrous roots. The roots do not usually penetrate this substratum to any extent, consequently the trees are often shallow-rooted in orchards where the layer of marl is close to the surface. The level of the lowest roots on one dying tree was only ten inches below the surface of the soil. At this depth they branched out horizontally, where they were readily injured by lack of moisture and by the action of frost. But a more immediate cause for this condition of the trees is found in the water supply. Water is plentiful during the early part of the season, but in the latter part of June the supply has usually been exhausted. The nature of the soil is such that it readily dries out and the trees suffer for moisture, consequently growth stops and the tissues harden. In the latter part of July a partial supply of water is again turned into the ditches and the orchards are irrigated. The result is that in many instances these trees make a distinct second growth which is immature when cold weather comes on. Those branches which are not killed outright but are severely injured during the winter put forth a feeble growth the following spring. The end bud, usually being the strongest, lives at the expense of the others, consequently many of the side buds soon die if they start into growth at all, and the terminal one develops a contracted branch on which the leaves are crowded, thus forming the rosette.

Second growth is not always necessary, however, for the appearance of this disease. Shallow-rooted trees planted in a soil that is quickly dried out are easily injured during the winter. This probably accounts for the fact that the disease first attracted general attention after the hard winter of 1898-99.

One orchard was visited in which a small number of diseased branches had appeared, but which had been promptly removed or severely cut back early in the spring. At this date, October 5, the

trees appeared to be perfectly healthy and had made a vigorous growth which showed no sign of disease. This experiment tends to confirm the conclusion that the difficulty is due to local conditions and not to a specific organism which might spread to other portions of the valley.

Apparently the same difficulty is figured and described in a recent *California bulletin in which the author ascribes the cause to the presence of alkalies in the soil. He states that apple trees are injured "by 1,200 pounds of carbonate and 3,000 pounds of common salt per acre distributed through four feet depth."

The particular soil on Rogers Mesa that was examined contained 1,820 pounds of common salt per acre taken to a depth of one foot. While this is a much larger amount of salt than the trees are said to be able to endure in California, most of the trees do not show any sign of the affection, though they have been planted nine years. This statement is confined to the first foot of soil, because it is doubtful if there is any portion of the orchard where the soil is four feet deep. Moreover, the subsoil is a marl into which the trees had thrown very few roots.

The amount of sodic carbonate in this soil was not determined. However, we have had occasion to observe a nursery that was established in a soil in which the sodic carbonate content was determined and found to be 2,800 pounds per acre, taken to a depth of four feet. The trees made an excellent growth for three years and showed no sign of the rosette affection.

While these observations do not prove that this condition of apple trees may not be produced by the action of alkalies, they point to the conclusion that such an effect is improbable under our conditions.

Treatment.—Apple trees should not be planted on soil where the marl substratum comes close to the surface, as it will result in shallow-rooted trees with its attendant evils. In other portions of the district an attempt should be made to make the soil deeper and to add to it substance and fiber. Many Colorado soils are deficient in vegetable matter, consequently they become compact and dry out rapidly. Depth may be gained by plowing deeply before the orchard is planted, and vegetable matter added by turning under strawy stable manure or green manure. For the latter purpose some form of clover, vetch or rye may be used, preferably in the form of a cover crop, which should be sown in the latter part of summer and plowed under during the following spring. If water for fall irrigating is available the crop will make growth sufficient to afford considerable protection to the roots against the action of frost and from drying out by winter winds. Finally, by a judicious use of water, of which

*Laughridge, R. H. "Tolerance of Alkali by Various Cultures." Calif. Agri. Expt. Sta. Bull. 133:14.

PLATE IV.

Fig. 1. Cherry tree injured by mound parasite.
Fig. 2. Detail of apple limbs shown in Plate II.

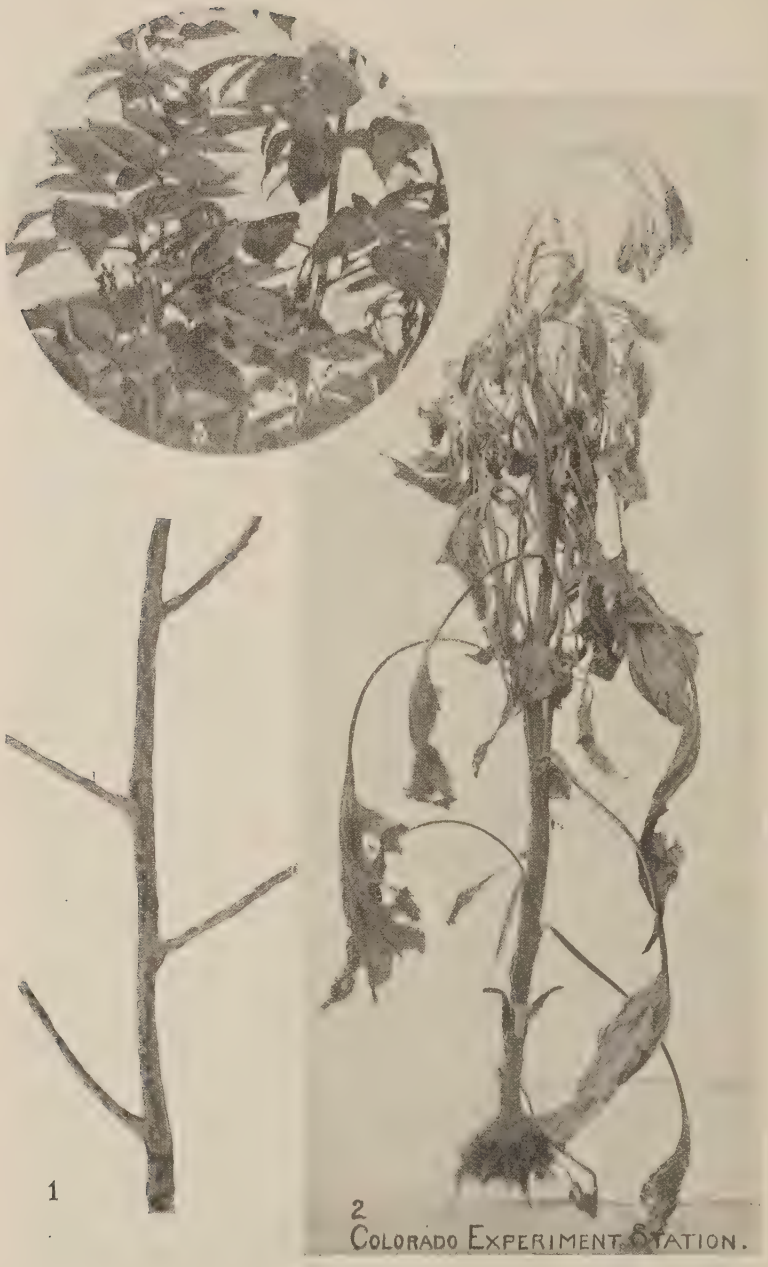

PLATE V.

Fig. 1. Spore pustules of rust fungus on branch of Asparagus. Enlarged.

Fig. 2. Aster killed by Fusarium.

Fig. 3. Raspberry leaves curling at edges. The result of an attack of Rhizoctonia on the roots.

an abundance is promised the Mesa for the coming season, it is not likely that this disease will be very injurious on soils that are of sufficient depth to make suitable orchard land.

APPLE INJURY FROM SPRAYING WITH BORDEAUX MIXTURE.

Complaints were received from correspondents at Canon City and Montrose that spraying with Bordeaux mixture had seriously injured the fruit of certain varieties of apple trees. The injury produced is well shown in the illustration in Plate VIII., Fig. 3, which is from a photograph of a Ben Davis apple that is so disfigured as to be unsalable. This variety appears to be very susceptible to such injury, though a number of other kinds were injured more or less. All degree of disfigurement occurred, from a slight russeting of the skin to the malformation shown in the figure.

That the corrosive action of Bordeaux mixture is responsible for this condition there can be no doubt. The subject has attracted considerable attention in the Eastern States, where it has been found that such injuries are much more common in some seasons than in others. Just what the conditions are that favor this action of the mixture have not been determined and the subject is still in an experimental stage. This is particularly true of the arid regions, since fungicides are just beginning to be used here on fruit trees.

In the light of our present knowledge, it can only be recommended that great care be taken to see that the mixture is properly made. The formula on a subsequent page has been found to be sufficiently strong for combating fruit-tree diseases as they occur in other States. Further experience with spraying in Colorado may show the necessity of modifying the formula to suit our conditions. And, finally, Bordeaux mixture should not be used unless it is needed. In the vicinity of Canon City it is said that the bitter rot of apples is abundant and the orchardists sprayed their trees with the mixture for the purpose of combating this disease. But in the majority of the fruit growing districts apple trees are not yet affected to any extent by such plant diseases as can be controlled with Bordeaux mixture.

BLACKBERRY ROOT DISEASE.

(*Rhizoctonia.* Sp.)

There was a noticeable amount of light green or yellowish foliage on the blackberry and raspberry plants in the College plantation last spring, which did not regain its normal color. Later in the season leaves on occasional plants began to curl and shrivel as though suffering for moisture, and some of the plants died. Appar-

ently healthy plants exhibited this latter symptom. (See Plate V., Fig. 3). Upon examination, the bushes were found to be attacked by a root fungus which is closely related to the one which is so destructive to potatoes. (See Bulletin No. 70 of this Station). All parts of the plant below ground were attacked, but the greatest injury occurred on the canes above the crown. Here, as shown in the illustration in Plate III., the bark was discolored and shrunken from the crown to the surface of the soil, or a short distance above. The fungus grows on and within the bark, destroying the tissues, and thus interfering with the movement of plant food. The injury commonly extends around the cane, and when it becomes deep enough to cut off the supply of moisture and food, the plant dies.

The presence of the yellowish foliage was probably due to a badly diseased root system at the beginning of the season. An excess of moisture in the early part of the season was favorable to the growth of the fungus, which made rapid inroads on the plant's vitality. That they were poorly nourished, was indicated by the yellow appearance of the leaves.

The drying up of leaves on apparently healthy canes may have been due to a vigorous attack of the fungus which, because of favorable conditions, was able to seriously injure the plant in a short time.

This fungus, *Rhizoctonia*, is destructive to a great variety of plants, and it is widely distributed in the State. There are possibly several species of the fungus, which may be destructive to different plants. Little is known about the disease, and some investigators regard it as a sterile fungus, or one that produces no spores. But our investigations indicate that *Rhizoctonia* is but a stage in the development of a fungus of which some species are well known under another name.

There is no way of curing diseased plants, nor a practical means of preventing the disease from spreading after it makes its appearance in a plantation. It is a wise precaution to destroy all affected plants, but even this severe measure will not rid the soil of the fungus. New plants filled in such vacancies are liable to become diseased in a short time. It has not been determined how long the fungus will persist in the soil, but a new plantation should not be set on land where diseased plants have stood for at least four years.

It is undoubtedly the same fungus which attacks both blackberries and raspberries, hence raspberries should not be set on land where diseased blackberries have recently been grown, or *vice versa*.

Finally, when setting a new plantation, great care should be taken to get plants from stock that is known to be free from the disease.

CHERRY TREE WOUND PARASITE.

Mr. Hankins, Horticultural Inspector for Larimer County, called my attention to a disease of cherry trees in an orchard at Berthoud, where about fifty trees in a young orchard of sour cherries had been destroyed. All of the badly diseased trees then remaining were found to be injured on the trunks, similar to those shown in the illustration in Plate IV., Fig. 1. Large areas of bark had been destroyed which were still clinging tenaciously to the wood. The larger wounds were conspicuous, and when the dead bark was removed, as shown in the figure on the left, it was plain that these injuries were the cause of the death of the trees. In some instances, the trees were nearly girdled, but where the injury was of less extent, the loss of the bark, together with the drying out of the exposed wood, had interfered with the nutrition enough to kill the tree. All other parts were in normal condition.

The owner informed me that the orchard had been neglected and the trees bruised by careless hands while it was in charge of a renter. It is likely that such wounds afforded entrance to some fungus which belongs to a class known as wound parasites. These fungi are unable to penetrate living bark, but when they gain access to the tissues through a wound they are able to entend the injury. On examining closely, an abundance of white hypha was found beneath the dead bark, but what part the fungus took in the injury, if any, has not been determined.

Some neglected trees in the vicinity of Fort Collins were found which showed similar symptoms. These trees had been torn by wind and bruised by hail, thus producing wounds through which fungi could enter readily.

The loss of trees in the younger orchard would probably not have occurred if greater pains had been taken in cultivating. When wounds are accidentally or necessarily made they should immediately be protected by a coat of thick paint or grafting wax. By taking such precautions it is not likely that this disease of cherry trees will cause much damage.

ASPARAGUS RUST.

(*Puccinia asparagi*).

A portion of an asparagus plant, as shown in Plate V., Fig. 1, affected with rust, was received in October from a gentleman at Rockyford. This is probably the first time that this fungus has been reported from this State, and while it has done but little damage as yet, its presence here is of importance, as it has done a large amount of injury to asparagus plantations in other States. In some localities, where many acres of asparagus were formerly grown,

the crop has been practically abandoned because of the ravages of this disease.

The fungus has three stages in its development which appear at different times during the season. The form which usually attracts attention first comes on the canes rather late in the season, when numerous dark brown pustules are pushed out through the bark. These pustules are composed of masses of spores, as are also the dark streaks and patches of a still later stage, which also form on the canes.

These last spores remain on the brush or fall to the ground, where they are ready to spread the disease by attacking the new shoots the following season. The fungus lives within the tissues of the plant, and where badly affected the plant is so weakened that but little food is stored for the succeeding crop. This results in a reduced yield, and if the disease is not checked the bed becomes unprofitable and many of the plants are killed.

By way of prevention it has been suggested that the tops of the plants be cut off and burned early in the fall before the spores fall to the ground. This method has the disadvantage, however, of being injurious to the plants, as in order to be effective the tops must be removed before the plants are matured. This process may injure the plants nearly as much as the fungus.

* Sirrine reports flattering results in combating the disease on Long Island by spraying with a resin-Bordeaux mixture. (See formulas). He expresses doubt, however, whether this method will always pay, since the applications must be frequent and very thorough, thus involving considerable expense. In these experiments from three to five sprayings were given, beginning in July after the cutting season was over. In the case of small beds it will no doubt be a better plan to destroy the plants and start anew on uninfested soil.

ASTER WILT.

(*Fusarium.* Sp.)

The asters on the College campus were nearly all destroyed last season by a species of *Fusarium.* (See Plate V., Fig. 2). The plants appeared vigorous and gave promise of abundant bloom up to the time the blossoms were beginning to open, when many of them began to wilt and in a few days were dead. In no instance, so far as noticed, were isolated plants affected; in some beds all of the plants were killed, while in others only those in certain areas died.

On examination the stalks were found to be discolored for a space of one to three or four inches above the surface of the ground.

*N. Y. State Agr. Expt. Sta. Bul. 188.

The light pink spore masses of the fungus were very abundant on this area. It is likely that the disease was in the soil when the plants were set out and that it gained access to the plants through the crown or upper roots, as the root system was also badly diseased.

The fungus grows within the tissues and absorbs the nourishment of the plant. Finally the communication between root and top becomes obstructed by the collapse of cells and the filling up of the passages by the fungus hypha.

The only remedy that can be suggested for this disease, since the fungus lives in the ground, is to replace the soil in the beds with fresh earth. This would be practicable only with small beds. But it is possible that the soil can be freed of the fungus by taking certain sanitary precautions. Such measures would consist, first, in burning all diseased plants as soon as they are detected, thus preventing further dissemination of spores; second, asters should not be grown for two or three years in beds where the disease has appeared; the fungus will probably be starved out during this time.

CURRANT CANE DISEASE.

(*Nectria cinnabarina*).

Currant bushes in the vicinity of Fort Collins are seriously affected by a fungus which attacks the canes. It is especially severe on neglected bushes in back yards, but the College plantation, which has always been given good care, was so badly diseased that it was thought best to destroy it. The fungus was also found in an active condition on gooseberry bushes that stood in adjoining rows.

Yellow foliage and dying canes are characteristics of this disease, which often occur on a bush where a portion of the plant appears healthy. As is common with some other plant diseases, many of the canes die after the fruit becomes of considerable size and both fruit and foliage shrivel and cling to the stems. Badly diseased plants are frequently killed. The reproductive bodies of the fungus occur in great abundance on the dead canes in the form of brick-red masses or tubercles, which are shown natural size in Plate VI., Fig. 2.

*Spraying with fungicides is not likely to prove practical as a preventive of this trouble, as spores may be produced at any time during the season. All that can be done is to remove the entire plant and burn it as soon as any part shows evidence of the disease. If allowed to lie on the ground the affected parts may mature spores and spread the disease to other plants. It has been determined that the fungus lives from year to year within the tissues of the currant plant, and that a plant may be infested for some time without show-

*Durand, E. J. Cornell Univ. Agri. Expt. Sta. Bul. 125.

ing any evidence of disease. Therefore cuttings should not be taken from a plantation in which this fungus has appeared.

GRAPE ANTHRACNOSE.

(*Sphaceloma ampelinum.* De By.)

During the month of June the grape vines in the College vineyard were found to be seriously diseased with anthracnose as is shown in the illustration in Plate VII. Numerous dark colored pits or depressions occurred on the young canes and on the stems of the leaves and fruit clusters. Many of the spots grew into each other as the disease progressed, thus forming continuous depressions which in some cases nearly girdled the affected parts. The centers of the depressions also took on a whitish color, and finally very minute raised points or pustules appeared, in which the spores are born.

The first effect seen on the leaf blade was in the form of fine, irregular cracks with brown edges. Later in the season the leaves presented a torn and ragged appearance where two or more cracks ran together. Leaves attacked when quite young were severely injured and their surface materially reduced, as shown in the plate.

The characteristic appearance of diseased fruit is well shown in the illustration where one fruit is attacked and a seed exposed through a circular wound. The diseased berries do not decay, but the affected portions become hard and shrivelled.

In Europe, as well as in many portions of the Eastern States, this fungus has proven difficult to combat. When once well established in a vineyard it has usually taken two or three years of most thorough treatment to get it under control. Fortunately, however, the disease does not spread rapidly.

It is recommended that the vines be sprayed thoroughly with Bordeaux mixture, beginning early in the spring at the time when the buds are commencing to swell. This treatment should be followed by four or five others made at intervals of about two weeks.

PEA ROOT DISEASE.

During the season of 1900 Mr. C. H. Potter, assistant in Horticulture, gave considerable attention to a destructive pea disease which made its appearance in the vicinity of Longmont. The trouble was not generally distributed, but was confined to certain fields. In these fields where the disease was most severe a majority of the plants were killed before reaching the surface of the ground. Different fields presented all variations in the amount of injury, from partial to complete failures of the crop.

The disease was not so destructive last season, as only a few

fields showed evidence of its presence. I examined one tract of land that had been sown to peas at the usual time in the spring. Most of the seed failing to grow, the ground was plowed and again sown to peas. At the time of my visit the field had the appearance of fallow land, as only an occasional pea plant was to be seen.

The soil in the vicinity of Longmont is well adapted to pea growing, about 2,500 acres being grown there annually to supply the canning factory, which makes a specialty of this product. The fields in which the disease made its appearance have always produced good crops of other kinds. A good crop of wheat grew the year before on the one that I examined.

My attention was called to this disease first in September of 1900, when I took up the work of this department, but no investigations could be undertaken at that time. During the following winter some soil was secured from an infected field, which was placed in flats in the greenhouse and sown to peas.

The plants grown in this soil were nearly all attacked by fungi on the roots and on the stems below ground. The injury was not severe enough, however, to kill them, and as the vines grew and bent over they were attacked at the point where they came in contact with the earth. These diseased areas were soon overrun by various saprophytic fungi, so it was difficult to tell what was the real cause of the trouble. However, there was a large colored hypha constantly present in the diseased parts and the same hypha was found to be abundant in specimens collected in the field by Mr. Potter the summer before and preserved in formalin.

All attempts to cultivate the fungus artificially failed, since it produced no spores and the diseased areas on the stems were so contaminated with other forms that efforts to secure cultures by other means failed. The distinctive character of the hypha showed that it belonged to a group of fungi commonly known as *Rhizoctonia*, and that it was closely related to if not identical with the disease that is so destructive to potatoes in this State.

The soil was then turned over to Mr. Rolfs to determine whether it was infested with this potato fungus with which he was working. A part of it was placed in pots and planted to potatoes. Eight pots were planted with clean potatoes that had been treated with corrosive sublimate to free them from disease. The soil in another lot of eight pots was sterilized with steam for three days, two hours a day, to kill all plant life that it contained. These pots were planted with clean potatoes treated as above. In the first series all the plants were affected with *Rhizoctonia*. In the second all of the plants, with one exception, were free from the disease. The presence of the fungus in the one pot may easily have been due to carelessness in watering, as it stood by the side of the others that contained the unsterilized soil.

Inoculation experiments were undertaken with potato *Rhizoctonia*, both with pure cultures and with the sclerotia as they occur on potato tubers. Peas were germinated in the laboratory and when the caulicle was about an inch long the inoculation was made. Some of the fungus from the cultures was placed between the caulicle and the cotyledons; then the peas were planted in coarse river sand in the greenhouse. Peas that were not inoculated were planted at the same time to serve as a check on the work. The result of the experiment shows that the fungus occuring on the potato is parasitic on the pea, as the roots of all inoculated plants were badly diseased and in some instances the caulicle of the young plant was cut off. But in no instance were the plants killed, as they threw out new roots above the injury and were able in a measure to overcome the disease. Roots of the pea plants that were injured by the fungus in these inoculation experiments are shown in Plate VI., Fig. 1. The check plants grown under the same conditions, but not inoculated, showed no signs of disease. These experiments were repeated and varied by placing portions of the fungus under both caulicle and plumule. *Rhizoctonia* sclerotia taken from potatoes and started into vigorous growth by placing them in a moist chamber over night were used in the same way; the results were the same as before.

These experiments do not prove conclusively that the so-called *Rhizoctonia* disease of potatoes is the cause of this trouble with peas, but the indications point strongly to this conclusion. It is known that this fungus is destructive to a great variety of plants and these experiments show that it may injure peas. That it did not kill the pea plants in the inoculation experiments may be due to the fact that conditions in the greenhouse were not suitable for the best development of the fungus. The failure of the fungus to kill the peas that were grown in the greenhouse in soil from an infested field must also have been due to unfavorable conditions.

As a result of these observations and experiments it is safe to conclude that the pea disease is due to a fungus that is in the soil when the peas are planted. There is no practical way of detecting its presence until its effects are seen on the pea plants, consequently the discovery of a method of treatment would seem to be a difficult matter; some suggestions, however, obtained from the study of other plant diseases may be of value.

First—The heavier soils should be avoided for pea growing, as root diseases, especially the fungus that attacks potatoes as mentioned above, is much more severe on such soils.

Second—By deep plowing the diseased surface soil may be buried so deeply that the fungus will not come in contact with the young roots. After the pea plants are thoroughly established it is probable that the fungus will have only a slightly injurious effect,

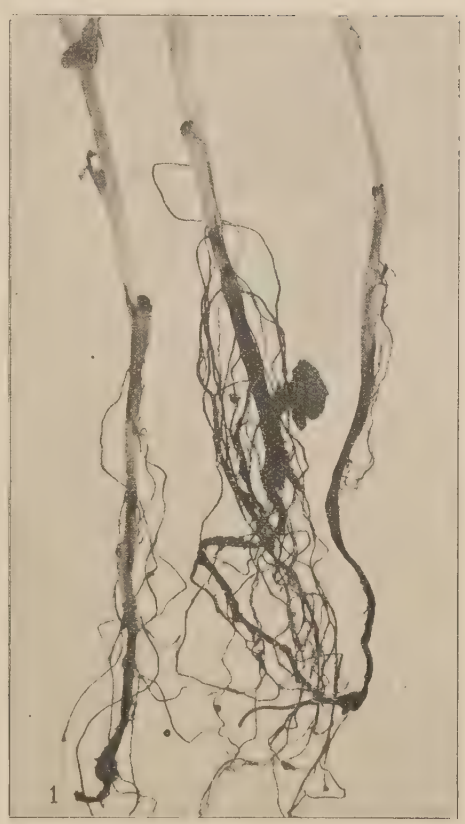

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PLATE VI.

Fig. 1. Pea roots injured by inoculating with Rhizoctonia from potato.

Fig. 2. Fruiting bodies of Nectria cinnabarina on currant canes. Both figures natural size.

PLATE VII.

Anthracnose of the grape. Showing injury to cane, leaf, leaf stem, fruit and stem of fruit cluster. Natural size.

as the experiments indicate that the disease is most destructive when the plants are small.

Third—As little water should be used in irrigating as can be gotten along with, since root fungi in general thrive best in a wet soil.

Fourth—It is within the range of possibilities to secure a variety, or strain of some variety, of peas that will resist the attacks of this fungus. Recent reported advances made in plant breeding encourages us to believe that such a strain may be secured, and we hope to undertake work of this nature the coming season.

PLUM LEAF BLIGHT, OR SHOT-HOLE FUNGUS.

A common disease of plum and cherry trees, known as leaf blight or shot-hole fungus, is illustrated in Plate IX., Fig. 1. A common effect of the fungus is to destroy small areas of leaf tissue, which drop out and leave circular holes, thus suggesting the name. When many of these holes run together the greater part of the leaf is destroyed. If the fungus is severe in its attack and the leaf surface is materially reduced during the active growing season great injury is done to the trees.

Numerous experiments have proven that this leaf blight may be easily controlled by spraying with Bordeaux mixture. *Beach recommends that three sprayings be made as follows: The first about ten days after the blossoms have fallen; the second about three weeks after the first, and the third about four weeks after the second.

This disease is reported as being quite abundant in some seasons in sections of Colorado. In such localities it will undoubtedly pay to give the treatment recommended a trial.

POTATO DISEASES.

Potato diseases are being made the subject of special investigation at this Station, as mentioned on another page, and a report of progress of the work is soon to be published in bulletin form. Whether the fungus that has been found to be so destructive to this crop can be entirely overcome has not been determined, but much good can be done by treating seed potatoes.

It is our purpose merely to call attention to the subject at this time, and for the sake of convenience, formulas for disinfecting seed potatoes are given on the following page.

*Beach, S. A. Rep. N. Y. State Exp. Sta. 1896, p. 399.

An extended discussion of this subject will be found in Bulletin No. 70 of this Station.

FORMULAS FOR TREATING DISEASED SEED POTATOES.

Corrosive sublimate.....1 ounce
Water.....8 gallons

Dissolve the corrosive sublimate in one gallon of hot water, then dilute with seven gallons of cold water. Allow the potatoes to soak one and one-half hours. When dry they may be cut and planted, though it has been found to be a good practice to treat the potatoes a week or more before planting, since the treatment may retard germination if done just before planting.

Corrosive sublimate is a deadly poison, and it should be used in wooden or earthen vessels, since it corrodes metals.

Formalin.....8 ounces
Water.....15 gallons

Soak the potatoes two hours in this solution, preferably a short time before planting. This remedy is somewhat more expensive than the corrosive sublimate treatment, but it has the advantage of being non-poisonous, and it may be used in any kind of vessels.

QUINCE RUST.

(*Gymnosporangium.* Sp.)

Last season the quinces in some sections of the Western slope were quite generally attacked by a fungus that is commonly known as rust. The fruits were often much distorted and worthless, as shown in the illustration in Plate VIII., Fig. 1. Any part of the fruits may be attacked, but in this case the blossom end was elongated into a hard knotty mass, on the surface of which was many fine tube-like projections about a quarter of an inch long, in which spores were produced. Fruits which were attacked when quite young were much dwarfed and so distorted that they scarcely resembled quince fruits. The fungus may also attack the stems and leaves of quince trees, but on the few trees that were hastily examined, it was only found upon the fruit.

The peculiar and interesting life history of this plant disease was worked out a number of years ago, which is briefly as follows: The fungus has two stages in its development, which are produced on two distinct classes of plants. The first stage occurs on cedar and juniper trees, on which it produces enlargments of the twigs and branches. The fungus lives year after year within the tissues, and the injuries are gradually extended until the branch or even the tree may be killed. Spores are given off in the spring of the year from conspicuous orange-colored masses which grow out from

the diseased parts. These masses are sometimes mistaken for blossoms or fruit of the tree, and in some sections are known as cedar apples. They are moist and gelatinous in texture during damp weather, so that the first spores readily germinate where they are borne. These in turn give rise to minute secondary spores, which are readily blown about by the wind and which can only grow on some plant that is a member of the family to which the quince belongs. When they chance to fall on a quince tree, and the conditions are suitable for germination, rust is produced. The cedar apples become dry and withered during sunny weather, consequently the dissemination of spores is stopped until another rain softens the mass. Thus it happens that the period of infection may extend over a considerable length of time.

The spores that are borne on the quince trees can only grow when they in turn are carried to the cedars, thus starting new sources of infection.

There are a number of species of this fungus and all of them pass the second stage on some member of the same family of plants. The apple is sometimes attacked, and the service berry that grows in the foot hills and mountains is often badly diseased. Fig. 2, Plate VIII., is from a natural size photograph of a pear that was received from Glenwood Springs, Colo., August 29. A portion of its surface was covered with the spore bearing projections similar to those on the quince. It is an uncommon occurrence, however, for pears to be attacked by this fungus.

Experimenters usually agree that spraying with Bordeaux mixture has little effect in preventing this fungus from attacking fruit trees. They all recommend that the cedar and juniper trees in the vicinity of an orchard be destroyed, which of course is a certain remedy. But since orchard trees have been known to be infected from cedars eight miles away,* this method would not be practicable in Colorado. The quince growing sections of the State are mostly in close proximity to the foot hills and mountains, the sides of which are covered with extensive cedar forests. * Bailey cites an instance in New York, however, where the rust was much less abundant in sprayed portions of an orchard than it was on the unsprayed trees.

There are no records of experiments on the treatment of this disease in the arid regions, but since the dissemination of spores from cedar trees is dependent on the rain fall, it is not probable that the fungus will be so difficult to control as it is in humid climates. For this reason, also, it is not probable that the disease will be so abundant every year as it was last, since it is likely that a rain came at the time which was most favorable for the development and spread of the spores.

* Bailey, L. H., Cornell Univ. Ag'l. Expt. Sta., Bulletin 80.

However, if it is thought best to try to protect the quince crop, the following line of treatment is recommended: Spray thoroughly with Bordeaux mixture as soon as the fruit has set, and follow this with two or three more sprayings at intervals of ten days or two weeks. The young fruit should be protected with the mixture until the season of late spring and early summer rains is passed.

STRAWBERRY LEAF BLIGHT.

(*Sphærella fragariæ.*)

The illustration in Plate IX., Fig. 2, is from a natural size photograph of a strawberry leaf that was attacked by the common leaf blight or rust. This disease is so common and the characteristic spots which it produces on the leaves are so well shown in the illustration that an extended discussion of the nature and effects of the fungus will not be necessary. It may attack any portion of the plant above ground, and when the leaf surface is materially reduced, small berries are the result. The fruiting stems may be so injured by the fungus that the berries wither before they ripen, and when newly set plants are badly diseased, the future crop may be a failure. Some varieties are much more susceptible to attacks of this fungus than others, and some valuable kinds have to be abandoned in certain localities on this account.

The degree of susceptibility that a variety exhibits toward this disease varies in different localities, but good kinds may be found for every locality which are comparatively free from attacks of rust. Selection of resistant varieties is the most practical method of combating the disease, but it may be controlled by spraying with Bordeaux mixture if it seems desirable to do so. When setting new plants, all diseased foliage should be removed and destroyed, and the plants should be sprayed a few days after setting. The new growth must be protected with the mixture during the fore part of the season. This will require about four sprayings. The next season it is recommended that the plants be sprayed just before they blossom and again as soon as the blooming period is over. If the plants are to be fruited another season, the beds should be mown and burned over as soon as the picking season is passed. If the burning is properly done no harm will result to the plants, and many spores of the fungus will be destroyed.

WHEAT STINKING SMUT.

(*Tilletia fœtens.*)

It is the practice of the wheat growers in many sections of the State to treat their seed wheat with copper sulphate (blue vitriol), for

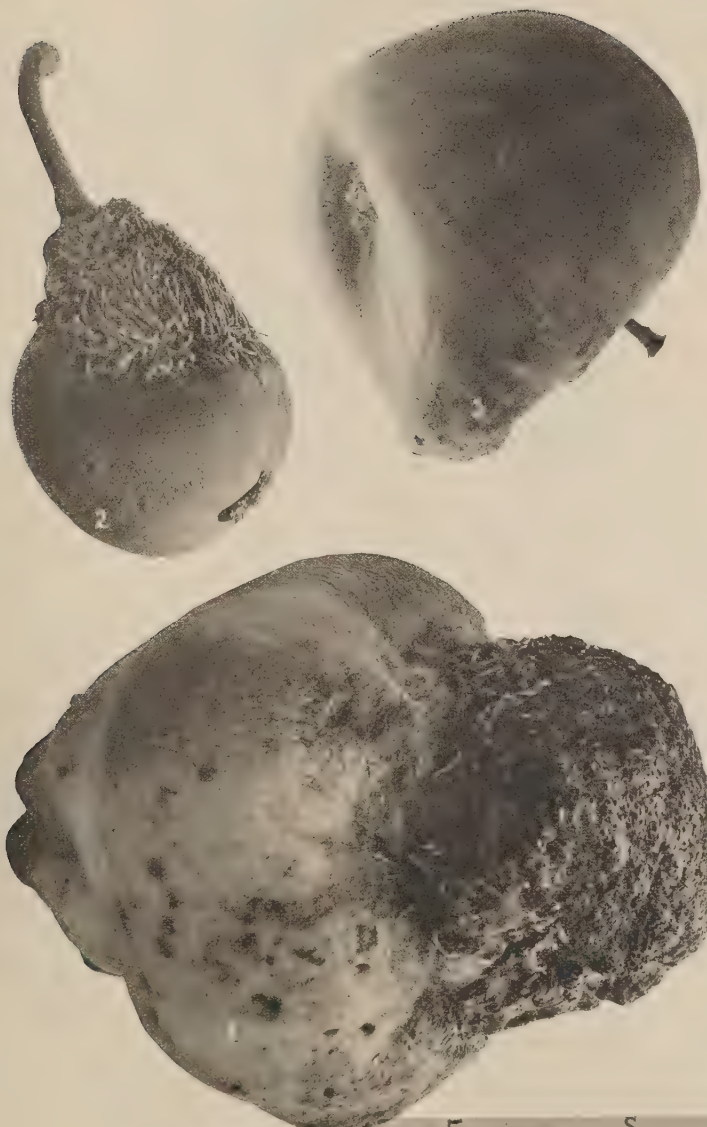

PLATE VIII.

Fig. 1. Quince attacked by rust fungus.

Fig. 2. Pear attacked by rust fungus.

Fig. 3. Apple injured by spraying with Bordeaux mixtures. All natural size.

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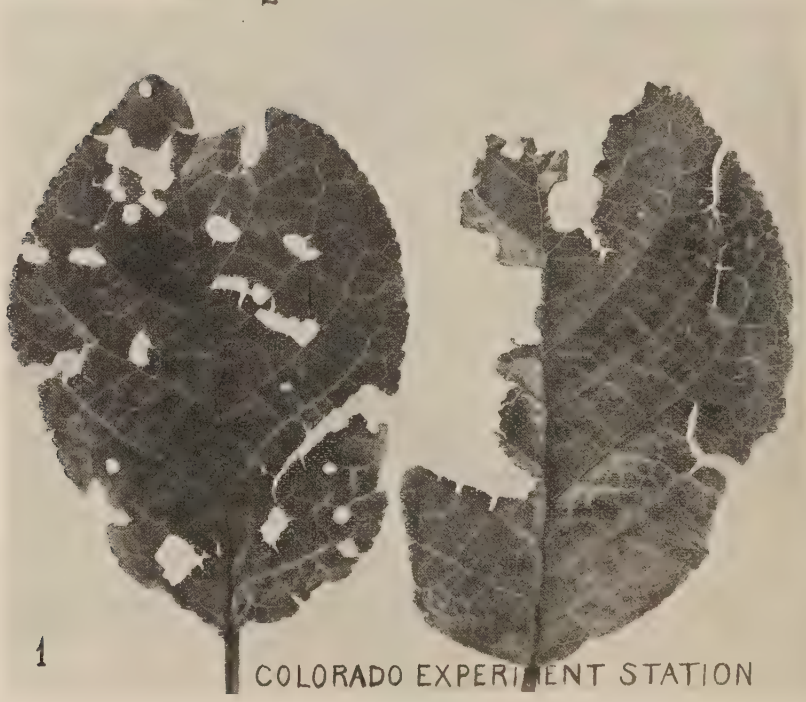

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COLORADO EXPERIMENT STATION

PLATE IX.

Fig. 1. Plum leaves injured by shot hole fungus.

Fig. 2. Strawberry leaf attacked by blight. Both natural size.

the prevention of smut. The results of numerous experiments and the experience of many farmers prove that there is no doubt of the efficacy of the treatment. However, occasional failures are reported, some growers claiming that they can see no advantage in the treated over the untreated seed. Such results indicate that the best methods of treatment are not understood by all.

We intend to test the different ways of combating wheat smut in the near future, to determine which one is best suited to our conditions. In the mean time, the latest formulas recommended by the best authorities are given below:

I.

Copper sulphate (blue vitriol).....1 pound
Water.....4 gallons

Dissolve the copper sulphate in hot water. Sprinkle or spray the solution on the wheat that has been placed in piles on the floor or on a canvas. Shovel the piles over while the liquid is being applied to insure the thorough wetting of every grain. Use no more of the solution than is necessary and spread out the piles so that the wheat will not remain wet long enough to become heated.

II.

Corrosive sublimate.....1 pound
Water.....50 gallons

To be applied in the same manner as the solution of copper sulphate.

III.

Formalin.....1 pound
Water.....50 gallons

Use the same as the other remedies.

Prof. Bolley, of North Dakota, who has experimented extensively with remedies for grain smuts, prefers the formalin treatment to any that he has tried.

FORMULAS.

BORDEAUX MIXTURE.

Copper sulphate	4 pounds
Lime	4 pounds
Water	45 gallons

The copper sulphate must be dissolved in hot water if wanted for immediate use. It may be dissolved by suspending it in a sack in the top of a considerable quantity of cold water, but this method requires a much longer time. If placed in the bottom of the vessel it will not all dissolve. The best quality of stone lime should be purchased, slacked and diluted till it is in the form of a thin whitewash. After the copper sulphate solution has been diluted to about thirty gallons, the whitewash is poured in, stirred thoroughly, and the mass diluted to the required 45 gallons. It is essential that both the copper sulphate solution and the whitewash be quite dilute before they are combined, otherwise a coarse precipitate is formed, which does not pass through the spray nozzles readily.

Where large amounts of Bordeaux are to be used, it is advantageous to keep on hand a stock of dissolved copper sulphate and of slacked lime. The stock of copper sulphate may be made by dissolving, say, fifty pounds in twenty-five gallons of water. Then one gallon of the solution will be equivalent to two pounds of copper sulphate, and two gallons will be required for a barrel of the mixture. The vessel containing the solution should be kept closely covered to prevent evaporation. It should be mentioned, also, that copper sulphate corrodes iron quickly, therefore it must not be allowed to come in contact with iron vessels or tools.

The lime may be slacked in quantities, when it will keep in good condition all summer, if it is not allowed to become dry. A chemical test for copper is taken advantage of to determine the amount of lime paste to be used. This is called the potassium ferrocyanide test. The chemical comes in the form of yellow crystals, and a few cents worth will suffice for the entire season. It should be dissolved in ten times its bulk of water when it is ready for use. A quantity of the lime paste in the form of a thin whitewash is added to the dilute copper sulphate solution, then the mixture is stirred thoroughly. A drop of the test is now allowed to fall on the surface of the mixture. It will instantly turn to a dark, reddish-brown color

if sufficient lime has been used. More lime must be added until the test shows no reaction, when the mixture is ready for use. A slight excess of lime will do no harm and will be a safe-guard against possible error.

Bordeaux mixture deteriorates rapidly, therefore it should be used on the same day it is made.

It is often desirable to apply poison to the same plants that are to be sprayed with Bordeaux. Fortunately the two remedies may be combined and both applied with one operation. Any of the arsenical compounds may be used, and at the same rate when mixed with water.

RESIN-BORDEAUX MIXTURE.

Recommended by * Sirrine for spraying asparagus, cabbage and other plants to which the common Bordeaux mixture does not readily adhere. Also as a poison carrier to make poison mixtures adhere to the same class of plants.

Resin	5 pounds
Potash lye	1 pound
Fish oil	1 pint
Water	5 gallons

Place the oil and resin in a kettle and heat until the ingredients are dissolved. Then remove from the fire, and when slightly cooled, add the lye slowly, while the mass is being continuously stirred. The water is now added and the mixture is boiled until it will mix with cold water, when it forms an amber colored liquid. Care should be taken at all times to keep the materials from boiling over and catching fire.

The above forms a stock mixture of which two gallons are used to forty-eight gallons of Bordeaux made in the usual manner. It is found best, however, to dilute the resin mixture with about eight parts of water before it was added to the Bordeaux.

The materials are used in the same proportions when Paris green or other similar poisons are being used on plants.

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* New York State Agri. Expt. Sta., Bulletins 144 and 188.